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RACIC report

WATER PROBLEMS OF THE MIDDLE EAST

Report No. BAT-171-38

Prepared Under Contract SD-171

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June 17, 1966

Director
Advanced Research Projects Agency
Office of the Secretary of Defense
Washington, D. C. 20301

Attention: Project AGILE

Dear Sir:

Enclosed are two copies of our report "Water Problems of the Middle East", BAT-171-38.

We will welcome any comments or suggestions you may have in regard to this study.

Sincerely,

John W. Murdock

John W. Murdock
Project Director
RACIC

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WATER PROBLEMS OF THE MIDDLE EAST

by

J. R. Irwin and J. A. Eibling

INTRODUCTION

This report presents a review of the water resources of the Middle East, their development in recent years, and their importance in the various countries of the region. The present study was authorized by a letter from Lt. Col. R. G. Harris on March 29, 1965, file number 03-91/65. This was in response to a previous RACIC report, "A Preliminary Survey of the Water Problems of the Middle East", transmitted February 23, 1965, which had contained three recommendations:

(1) Assess the water situation in each country individually

(2) Identify those countries in which progress in water-resource development and management is lagging

(3) Determine the steps which might be taken to stimulate progress.

The present study has attempted to carry out these recommendations, largely through a review of the available literature, supplemented by discussions with members of several agencies of the U. S. Government having interests in the subject matter and with one member of the United Nations staff. Because of the nature of the problem, the report includes some necessarily subjective interpretation of the significance of the available facts.

The report includes a general discussion of the region and its water problems, recommendations of means of bringing about improvements, and summaries

of the findings for the individual countries considered. These include the United Arab Republic (UAR), Iran, Iraq, Israel, Jordan, Lebanon, Saudi Arabia, and Syria.

OBJECTIVES

The objectives of the study were to review the water problems of the countries of the Middle East, identify countries in which progress in water-resources development and management is lagging, and determine steps which might be taken to stimulate progress in the problem areas.

SUMMARY

The status of water-resources development has been reviewed for eight countries of the Middle East. With the exception of Saudi Arabia, all of these countries have had active water-development programs in recent years, involving sizable construction programs and large expenditures of money. In several cases, the benefits realized appear to be less than anticipated. Possible explanations for the lack of progress are considered. It is hypothesized that the difficulties are partially attributable to shortages of trained people, particularly in administrative and policy-making positions, and to the widespread illiteracy in the region which has made it difficult to introduce modernization in agricultural practices.

CONCLUSIONS AND RECOMMENDATIONS

It has been concluded that much of the Middle East suffers less from an actual shortage of water than from failure to achieve maximum effectiveness in the utilization of the available resources. Weaknesses have been apparent in the planning and execution of projects and in obtaining the maximum benefits at the user level.

Because of the nature of the problem, no recommendations can be made which offer the assurance of a significant elimination of past malpractices. However, there are two approaches which appear to merit consideration:

(1) The establishment of a number of water institutes in the region. These would be technical organizations having the objectives of conducting and encouraging research in water-related problems, conducting field studies, training local personnel, and disseminating information to the public for the purpose of improving water-utilization practices. Consideration should also be given to including agricultural research as one of the functions of these institutes.

(2) The development of basic educational programs to reduce the high level of illiteracy.

The mechanism of acting on these recommendations will require further study. With regard to the establishment of water institutes, this might best be approached through formation of a committee representing a number of interested organizations, governmental and nongovernmental. The promotion of education in the Middle East is a formidable task. Here there appear to be at least two options:

(1) Make use of the native armed forces in those countries in which our relationship would permit it, by establishing educational programs for members of the armed forces and possibly by utilizing the more educated members of this group as teachers of basic subjects to the general population in the vicinity of military establishments

(2) Initiate a cooperative plan with established organizations (AID, UNESCO, various private groups) to develop programs of mass education.

THE GENERAL SITUATION

The Middle East is characterized by poverty, illiteracy, disease, and political unrest. It is not generally well endowed with those physical attributes which are commonly associated with successful economic development, such as a mild climate, mineral resources, and fresh water. In viewing the region's problems broadly, there is a temptation to blame them on these physical characteristics, particularly the widespread shortage of fresh water. However, closer observation leads to the conclusion that this is a gross oversimplification. For example, the shortage of water is not universal. Iraq and, to some extent, Syria have reasonably adequate supplies of water, but are not noticeably more prosperous, and certainly not more politically stable, than their neighbors. Oil income has been an important and increasing source of revenue during the past 20 years, in which almost every country in the region has shared in one way or another. In some countries the oil income has been used to finance large public works programs, including irrigation projects. These programs have not been remarkable in improving the general standard of living, although they have been beneficial.

Two countries of the region, Lebanon and Israel, stand out as exceptions to most generalizations. The Lebanese economy is based to a large extent on international trade and financing. The manufacturing sector is developing rapidly. A large percentage of the population is engaged in farming, but the emphasis is on high-value crops and relatively advanced agricultural techniques.

The literacy rate among the adult population is estimated to be at least 50 percent and possibly as high as 80 percent, and health standards are relatively high.

Israel is a classic example of the application of technology and enlightened management in creating a thriving nation in the face of serious environmental and sociological obstacles. Water resources are extremely limited. Population has grown, largely through immigration, from 1.2 million in 1950 to about 2.4 million in 1965. A large percentage of the immigrants have been illiterate and have come from Asian and African countries having poor health standards and undeveloped economies. Yet, Israel has used its natural resources with outstanding effectiveness. The people have a standard of living much higher than in the typical Middle Eastern countries, the literacy rate is about 95 percent, and health statistics compare favorably with those of the most advanced nations. At the same time, the country has not been plagued by the political instability so common in the region.

It might be argued that Israel is a special case because the people are bound together by religious ties, many of them have settled in the country as an escape from, or an aftermath to, persecution, and considerable financial and technical aid has been received from outside sources. The enmity of the neighboring countries, which has engendered a constant sense of national danger, has probably been a positive factor in building a national unity and a will to succeed.

Most of the other countries of the region appear to have somewhat comparable advantages--unity of religion, financial benefits from foreign aid or from oil income, outside technical assistance--and, in some cases, a strong historical tradition or sense of nationality, and yet have made little real progress.

Why is this so, and what part does water play in this situation? Obviously, there is no simple answer. One thing is certain, however: there are deep-rooted economic, sociological, and political problems in the region which are not going to be resolved merely by programs to improve the supply and utilization of water, however extensive and ambitious such programs might be.

Many of the great public works programs of the past 20 years have not produced the expected results. Some of the difficulties encountered have been administrative and some have been technical. The latter have included faulty operation and maintenance of irrigation systems, lack of drainage for irrigation water, and inadequate technology in farming methods. Water is an important element in farming in semiarid regions, but not the only element. Farmers must use fertilizers, good seed, correct irrigation and drainage practices, and other techniques of modern agriculture. Generally, the farmers of the Middle East are poor and illiterate tenants, lacking the knowledge and the incentive to adapt to modern ways. Government programs do not appear to have gone far enough to remedy this situation.

There is another less obvious aspect of the educational system which might have some bearing on the problem. Traditionally, education in these countries has been limited to the small wealthy class. These people have never been strongly attracted to technical education, either on the professional or subprofessional level. For example, in one of the prominent universities with an enrollment of 6,500 students, 2,500 were studying law, 700 medicine, 2,000 fine arts, and 100 engineering. The educated people prefer to serve in the Army or in the government. Consequently, government bureaus are often structured to make room for the available people, who are lacking in technical training. These people become the ones who make the laws, and the policies, and plan and administer the development programs, often with less than satisfactory results. This

relatively small group is politically concerned and active, while the masses of the people generally are not, which is at least partly responsible for the political instability which is prevalent in the region. The elements which are normally expected to add political stability to a country, such as an interested and informed electorate and a strong middle class, are generally not found in the Middle East.

In searching for solutions to the water supply problems, it is essential to consider what our overall objectives should be in this region. Presumably, we would like to see every country achieve internal political stability, with a pro-Western, or at least noncommunist outlook. Improved living standards for the people and a peaceful relationship with neighboring countries also appear to be desirable goals. State Department Publication 7706 indicates that our objectives are to seek peace and prosperity for everyone, to contain the spread of communism, and to encourage all people to improve their own lot without outside interference. Programs undertaken to improve the supply and utilization of water should seek to advance these goals, while at the same time recognizing the realities of the political relationships which exist in the region.

POSSIBLE MEANS OF IMPROVING THE WATER SITUATION

From a country-by-country review of water resources and their utilization, it appears that the water-related problems are generally not due as much to water shortages as to inadequate management and application of the available resources. If this observation is valid, then it follows that more gain can be realized per unit cost through programs of education, training, and research than from investments in physical works. Thus a "Middle East Water Institute", appears to be a most worthwhile venture. Ideally, it appears that the functions of such an institute should encompass a number of areas, such as:

(1) Fundamental research in the appropriate fields; that is, hydrology, hydrogeology, geology, geochemistry, civil engineering

(2) Advanced training of local technical personnel

(3) Field investigations of problems appropriate to the region

(4) Research in agricultural problems, particularly in irrigation techniques, fertilizers, development of improved plant varieties, etc. (with this function included, the proposed institute might be called a "Water and Agriculture Institute")

(5) Operation of model farms to demonstrate the merits of advanced techniques

(6) Operation of an agricultural extension service; or possibly a traveling seminar to demonstrate modern techniques to the farmers.

Any efforts to upgrade the agricultural economy of these countries will be hampered by the illiteracy of most of the farmers. There is a real need for a

massive educational program. Some efforts have been made and are being made by the local countries and by the U. N., but results to date have not been particularly fruitful. The magnitude of the problem can be appreciated when it is realized that the eight countries considered in this study have a combined population of about 75 million, of whom at least 55 million are illiterate. Furthermore, the population is presently increasing by about 2 million people per year. The effectiveness of programs to introduce technical improvements, whether these be the construction of major dams and irrigation projects or the establishment of specialized institutes, could be greatly enhanced if the intended beneficiary, the farmer, could understand and appreciate their significance.

The mechanics of organizing a water institute (or a water and agricultural institute) will require careful consideration. Some of the questions which must be answered include:

(1) Would it be better to establish one regional institute or one institute in each country? Normally, one large organization would appear to be more efficient, but there is danger that it would become more concerned with the water problem of the particular country in which it is located than with regional problems. Travel and communication between countries might also become awkward. A network of institutes, with periodic meetings between them, offers some advantages.

(2) How should the institute be staffed? Should it be all local nationals, should there be a U. S. cadre, or should it be broadly international?

(3) How should it be presented to the governments concerned? There are several countries in the region where a U. S.

> Department of Defense installation would not be warmly received. On the other hand, if it is to improve the U. S. image in the region it should carry some U. S. (rather than U. N., for example) designation.

These questions appear to involve policy decisions, and coordination between U. S. Government agencies, and cannot be answered in the present report. They are brought out to illustrate the complexity of the factors which must be considered if the water-institute approach is to be followed.

COUNTRY STUDIES

United Arab Republic

The United Arab Republic occupies an area of approximately 385,000 square miles. Population is about 30 million, with a net annual growth rate estimated at 2.5 percent. Literacy of the adult population is fairly low, about 20 to 25 percent. Public health standards are low by Western standards, but somewhat better than some of the other Middle Eastern countries. The already high rate of population increase is expected to become even higher as improvements in hygiene, sanitation, and disease eradication reduce the very high death rate, particularly the infant mortality rate.

The country is marked by many contrasts. More than 90 percent of the population lives in the Nile valley, where more than 6 million acres are irrigated by water from the Nile. This has traditionally been the foundation of the Egyptian economy and in past ages provided a reasonable living to the people. The main problem now is that the population has outgrown the resources.

Under a strong and aggressive central government since the 1952 revolution, a number of measures have been taken to provide alternative means of support.

These fall into two major categories--establishment of an industrial base to reduce the reliance of the economy on agriculture, and provision of water to once-desert lands to increase food production and reduce population pressures in the Nile valley. The industrialization drive has made good progress, making the UAR the largest industrial producer of the Middle East. The value of industrial production has tripled since 1952. Present industrial employment is about 750,000. Nevertheless, about 70 percent of the national income is still derived from agriculture.

Government programs have attempted to stimulate agricultural production through the dissemination of new techniques and modern equipment, establishment of cooperative organizations, and extension of irrigation. The most striking gains have been from the reclamation of former desert land. In the New Valley of the Western Desert, the exploitation of untapped groundwater has permitted the irrigation of about 300,000 acres of previously uncultivated land. The water contains some iron and sulfur and is corrosive, but agriculturally is of good quality. The soil is fertile and crop yields are high. New villages, roads, power stations, etc., have been built, and farmers have been settled on the land, generally on 10-acre plots.

The activity is directed by the Egyptian General Desert Development Organization, founded in 1959. Technical assistance in preliminary studies and in development of the water has been furnished by UNESCO and the U. S. Agency for International Development. Preliminary work included water surveys, gelogical studies, land surveys, soil classification, crop selection, and selection of irrigation methods. Well-drilling teams have generally consisted of one American and thirty Egyptians, using U. S. equipment.

By far the largest water-related project undertaken in the UAR is the construction of the High Aswan Dam. When completed it will regulate the flow of the

Nile, and provide water for the perennial irrigation of 1.3 million acres of presently barren land. An additional 700,000 acres will be changed from seasonal to perennial irrigation. The amount of land under cultivation in the UAR will be increased approximately 25 percent. The power potential is estimated to be 10 billion kilowatt-hours per year, about twice the current total power production in the country. Cost of the project is estimated as $1.3 billion, with about two-thirds paid by the UAR and the rest mostly by the USSR, which has provided considerable technical support and equipment.

Another large program under consideration is a plan to divert large quantities of the Nile to irrigate 1.2 million acres southwest of Alexandria. Cost is estimated as $600 million, to be financed entirely by the UAR.

Early in 1965, the UAR government requested bids for a nuclear power and water plant to produce 15 megawatts of electrical power and 56 million gallons per day of fresh water. The plant was to be located at Borg-el-Arab, between Alexandria and El Alamein. Cost was estimated to be approximately $38 million. This was reported to be the first of a series of five similar plants. Bids were received but procurement was cancelled to allow more study of the situation by the UAR government and by the U. N.

A number of water-related studies are being conducted by the U. N., including the economics of using desalinated water in the eastern desert and the Sinai peninsula, drainage methods and practices in the Nile delta area, and a pre-investment survey of the northwest and coastal regions, including hydrogeology, groundwater development, water conservation, and irrigation agronomy. The latter study has an allocation of $850,000.

The UAR has received some technical assistance from the Community Water Supply Development Program, an activity sponsored by the World Health Organization and the U. S. Agency for International Development for the purpose of promoting

improvements in urban water-supply systems. Apparently, the UAR is relatively well advanced in this respect. As of 1962, about one-third of the population was classified as urban. Of this number, 80 percent of the people were served by water piped into their homes, another 10 percent by public outlets located in close proximity to their homes, and 10 percent were not served. By 1977, the urban population will increase by 7.3 million people (a 74 percent increase). An investment during that period of $206 million will be needed to provide adequate service.

Compared with the other peoples of the Middle East, the UAR has a good nucleus of technically trained personnel and an aggressive government policy toward their water problems. They have much to gain from the development of new water supplies. Most of the population has always lived in a very small portion of the total land area, in the Nile valley, while the remainder of the land has been essentially barren. Experience in the recent development of groundwater resources in the desert indicates that much of this barren land might be highly productive when water becomes available.

Projects now under way are apparently being well executed and are contributing to the agricultural potential of the country. They appear to make good use of the technical and financial help available from both the Western and Communist countries and from the U. N. As in many countries, national policy occasionally seems to be directed toward programs which are motivated by political or psychological considerations, rather than sound economics. There are indications that the industrialization program has been extended beyond sound economic bounds, resulting in balance-of-payments problems. Meanwhile,

agricultural production has not been able to keep pace with the growing population, necessitating sizable imports of basic foods.

Even the successful execution of a few large projects will not provide a solution to the country's problems. The High Aswan Dam project, which is a gigantic undertaking by any standards, will provide irrigation for a little less than 1 percent of the total land area. While this represents a 25 percent increase in irrigation area, the population will increase by a roughly comparable amount during the construction period.

There are a number of measures which would contribute to improved living standards in the UAR. Probably all of these have at least been considered before:

(1) Population control. The UAR is feeling the effects of rapid population growth to a greater extent than any other country of the region. However, this subject is beyond the scope of the present study. It is mentioned because it is an all-important ingredient in shaping the future of the UAR. The prospects of significant progress in this field in a poor and largely illiterate country are not encouraging.

(2) Migration, or resettlement of excess population. This is somewhat an alternative to (1). Nationalistic sentiments, inertia, international suspicion, and the poverty of neighboring countries greatly diminish the probability of success with this approach.

(3) Expansion of agriculture through complete inventory and judicious use of water resources, somewhat as has been done in Israel. This is probably the most feasible approach to improving the situation. A massive technical effort would be required to locate groundwater supplies, evaluate safe

discharge rates, plan for effective distribution of both groundwater and Nile water, realistically evaluate the position of demineralized water in an overall water-utilization program, etc. Some work is now under way (the New Valley project, U. N. surveys of resources) in these areas, but an intensification of effort appears to be justified.

(4) Studies of water-conservation methods, particularly with regard to agricultural practices. This should include irrigation techniques and practices, crop selection for greatest crop value per unit of water, evaporation reduction, etc.

Iran

Iran is the second largest country of the region (after Saudi Arabia), with an area of 630,000 square miles, and the second most populous (after the UAR), with a population of about 20 million. Although 50 percent of the country is considered to be absolute wasteland, the amount of cultivated and potentially cultivable land is probably the highest in the region, on a per capita basis. For various reasons, including lack of irrigation water, a harsh climate and inefficient agricultural techniques, the farmers, who make up about 75 percent of the population, have a very poor standard of living. Per capita income is among the lowest in the region.

Ancient Iran (Persia), like ancient Iraq, was a rich and powerful country, with a thriving and productive agricultural economy, based mostly on irrigation. The Khuzistan province in particular, in southwest Iran, was once the principal supplier of food to Persia. Irrigation dams and canals were in

operation 2,500 years ago. As the fortunes of war and politics shifted, the irrigation system was neglected and the land reverted to desert.

Since 1948, when the Plan Organization was formed to expedite economic development, a major effort has been under way to revitalize the country. As one might anticipate, the road back has been strewn with obstacles. The ignorance, poverty, and decay built up over a period of centuries cannot be eradicated overnight.

In pursuing its development plans, the Iranian government has invested heavily in water-resources development for irrigation, power, flood control, and community supplies. Programs have not always moved smoothly from planning to execution to ultimate utilization. Lack of coordination among various government agencies involved in water problems, poor planning, unrealistic cost estimating, differences of opinion between the Iranians and foreign contractors, and lack of follow-through down to the level of the individual farmer have all contributed to the problem. Nevertheless, some impressive projects have been undertaken. The largest and most interesting is the program for the regional development of the Khuzistan area. The Plan Organization contracted with an American Company in 1957 to study the region and formulate a comprehensive economic development plan. The scope was later broadened to include supervision of the early stages of construction. The plan envisioned 14 dams on the region's five rivers to provide irrigation water, flood control, and power, as well as exploitation of the other resources of the region through development of an industrial complex. The first and largest of the dams, the Shah Pahlavi on the Dez River, was completed in 1963, at a cost of $62 million. The World Bank loaned $42 million, and the balance came from oil revenues. Other parts of the project have been initiated. Expenditures up to 1963 were $150 million. In 1963 control of the program passed from the American company to the Khuzistan Water and Power Authority, created by the

Plan Organization for this purpose. Included in the ultimate objectives of the program is the irrigation of 2.5 million acres of previously unproductive land of which 320,000 acres will be served by this first dam. Storage capacity of the reservoir is 3,350 million cubic meters. Potential power capacity is 520 megawatts. One American participant in the program characterized its success as being attributable to the personal backing of the Shah, and in spite of the lack of support and sometimes opposition of "an inflexible, entrenched, and largely incompetent bureaucracy".

Another regional development effort of a less ambitious nature has been initiated in the Sistan-Baluchistan region in the southeast. This is more of a rehabilitation program to improve an area which is already being farmed but is unproductive. Plans include improvement and extension of irrigation canals, surveys of groundwater resources, and construction of flood-control works and domestic water-supply systems.

The dam project at Sefid Rud, 150 miles northwest of Teheran, will provide irrigation water for 625,000 acres in the Caspian Sea region (Guilan Province), plus an eventual power output of 110 megawatts. Storage capacity is 1,780 million cubic meters. The original cost estimate was $30 million, but actual cost was about $63 million, excluding $45 million for the irrigation and power-distribution systems. The dam was completed in 1963.

The Karadj Dam, near Teheran, was built primarily to provide municipal water to Teheran, at a cost of $55 million. Some peaking power is also provided. Storage capacity is 205 million cubic meters. Design and construction were by American firms, and some U. S. money was involved. Completion date was 1961.

The Karkheh irrigation project, completed in 1955, involved a barrage and regulating gates on the Karkheh River and two main canal systems. Designed to irrigate 200,000 acres, the actual area irrigated 5 years after completion

was 22,500 acres. Apparently there were administrative problems in distributing the land to the farmers, and also a neglect of the drainage problem with the result that the land which was irrigated soon became waterlogged and useless.

A number of other irrigation and water-supply projects of lesser magnitude are in the planning or early construction stage.

Even before the modern drive for development, Iran had a considerable area of irrigated agriculture, with the water supplied mostly by ghanats. A ghanat is a system of wells and tunnels whereby groundwater is led from a higher elevation over a considerable distance (all underground) to an eventual discharge point in a hillside. From there it is usually conducted in open troughs to the eventual point of use as irrigation water or community water supply. The method dates back to antiquity. A recent estimate stated that 22,000 ghanats are in use, with a total flow of 560 cubic meters per second, irrigating 3.75 million acres, and providing municipal water to a large proportion of the population. There are also 1,300 wells providing drinking and irrigation water.

Because of the success of the ghanat system, it is generally assumed that there are appreciable groundwater reserves in Iran. The government is undertaking to assess and exploit these reserves, with technical help from the U. N. and the U. S. There is also an effort to improve the collection of hydrologic data, to improve the understanding and future utilization of the country's total water resources. Actually, some stream-flow data are available from as far back as 1894, and some rainfall data go back 50 years. Snow surveys were started in 1957. A Geological Survey Institute was recently established, with U. N. assistance.

In 1961, the U. S. Army Corps of Engineers was drilling wells to provide water for 30 military bases being constructed for the Iranian armed forces.

The U. S. Agency for International Development has assisted in the planning and construction of modern community water-supply systems. Except for the major cities, water supply in the past has normally consisted of untreated water from ghanats or from dug wells, or water delivered by a water seller. Even the new systems are crude by U. S. standards, generally supplying about 20 gallons per person per day through street fountains. However, the quality is monitored and treatment is provided to make it safe.

Iraq

Iraq has perhaps the greatest potential for economic development of any of the Middle Eastern countries. There are an abundance of arable land, two major rivers, and a number of smaller ones, and immense oil reserves. The present population is about seven million. Total area is 171,000 square miles, of which 20 to 23 million acres is cultivable. On a per capita basis, the cultivable area is about ten times that of the UAR. Oil income has been rising rapidly since 1950 and is presently about $300 million per year.

In spite of these advantages, the people of Iraq are no better off than most of their neighbors. The illiteracy rate is high even for the Middle East (85 to 90 percent). The general standard of living is low and agricultural productivity is low and has not risen even though large sums of money have been spent on irrigation works. The Iraqi government has encouraged, and in many cases subsidized, promising students to go abroad for advanced education, particularly in technical fields, and return home to aid in the development of the country. In 1956 there were about 1,000 Iraqi students in the U. S. As a result, a nucleus of trained people is gradually developing. It appears, however, that political problems have held back the expected development of the country.

In ancient times the region which is now Iraq (Mesopotamia) had the most productive and most highly developed agricultural society in the world. Irrigated agriculture is believed to have been practiced in this region at about 3500 to 4000 B.C. From 2400 B.C. to about 1300 A.D. this was a region of prosperity, and the prosperity was founded on irrigation. As long ago as 2500 B.C. the people built successful diversion dams and canals to transfer large quantities of water. During the Middle Ages, the situation deteriorated badly through neglect and poor administration.

There have been sporadic attempts during the 20th century to revive the once-productive agricultural economy. A diversion dam was built at Hindiya, on the Euphrates River, in 1913, while the country was under Turkish rule. This dam provided irrigation water for about 1.5 million acres. Under the British Mandate, from 1918 until the country attained its independence in 1932, Iraq was capably administered and some progress was made. After independence, politics began to play a dominant role. Great plans have been made and many dams have been built, particularly after the oil money began to be an important factor in the economy, but the overall picture has not yet improved appreciably. The Kut Barrage was built in 1939 on the Tigris River, downstream from Baghdad, to divert water for the irrigation of about one million acres. Under the control of the semi-independent Development Board, established in 1950, a number of important projects were initiated. These included:

(1) The Dokan Dam, in the Little Zab Riber, for irrigation and flood control and possibly hydroelectric power. Designed by the British and built by the French at a cost of $33 million, it stores 5,600 million cubic meters and provides irrigation water for 800,000 acres.

(2) The Derbend-i-Khan Dam, on the Diyala River, built for irrigation, flood control, and power. This was designed and built by U. S. companies, at a cost of $46 million. It stores 3,000 million cubic meters and provides water for 900,000 acres. Power potential is 112 megawatts.

(3) The Tharthar Barrage, on the Tigris River at Samarra, designed by the British and built by British and German contractors. This is a diversion dam, which diverts flood water through a 42-mile canal into a natural depression, where it evaporates. It also diverts water for irrigation. The cost was $26 million for the barrage and $18 million for the canal.

(4) The Ramadi Barrage, which diverts flood water from the Euphrates into Lake Habbaniyah, from where it can be fed into the Euphrates further downstream, or into a natural depression from which it will evaporate. Total project cost was $40 million. It was designed by the British and built by the French.

Other projects in the planning or early construction stages include:

(1) The Eski-Mosul Dam, on the Tigris, to store 13,800 million cubic meters for irrigation in the Jezireh region, scheduled for completion in 1968 at a cost of $170 million

(2) New irrigation works on the Tigris in the Kut area

(3) The Dibbis Dam on the Little Zab River, part of an overall plan for development of the Zab-Adhaim-Diyala region

(4) The Eski-Kalak irrigation project to serve 60,000 acres

(5) The Gharraf irrigation project, to irrigate 180,000 acres.

With all of this activity, it is pertinent to ask why conditions have not improved. There appear to be at least three identifiable reasons: poor administration, political unrest, and the ignorance and inertia of the rural population. These, and probably other reasons, are really all tied together. One major difficulty which has been experienced is loss of productivity due to soil salinity and waterlogging. This is a problem as old as the art of irrigation, and yet it continues to reappear. The soils of Iraq are especially susceptible to these ills, which can be avoided only by proper installation, operation, and maintenance of drainage systems. In the past the problem has been somewhat circumvented by cultivating the land only on alternate years, or by working a given piece of land until its productivity dropped and then abandoning it. In modern times, great irrigation projects have been built without adequate consideration of the drainage problem. In the 1950's, land ownership in Iraq was in the hands of a very few people. The average tenant farmer had little incentive or interest in maintaining the irrigation and drainage system. Following the 1958 revolution, laws were passed to provide for distribution of land to the farmers. However, administration of such laws is very difficult. As a result, the ownership of much of the land is now in doubt, which does not make for a productive atmosphere. Further, the peasants resist the introduction of improved farming techniques. For example, there was a report of the government distributing specially treated seed (apparently treated with pesticides) which poisoned some of the farmers when they ate it instead of planting it.

The changes in government have caused a shifting of development goals, a tendency to delay making important decisions, and turnover of key personnel, all of which add to the general confusion.

There are indications that conditions are improving. More attention is being given to drainage projects. A large number of wells are being drilled

to exploit the groundwater resources. The government is trying to organize farmers' cooperatives to aid in the modernization of agricultural practices. Whether major improvements in living standards will result remains to be seen. Major projects have been completed and more are under way, a nucleus of trained people is available, the oil money is available, expert advice is available from the U. N. and from the developed nations, and the land, water, and climate offer the prospect of a properous agricultural economy. The missing ingredients appear to be sound administration and the interest and support of the average farmer.

Israel

Israel is unique among the Middle Eastern countries in many ways. In an area of 8,000 square miles of what was once typical unproductive Middle Eastern land, the present population of over two million people has achieved a standard of living far above that of the neighboring countries. This has been achieved in spite of the influx of a million immigrants, many of them poor and illiterate. Today the literacy rate is about 95 percent, and health and life expectancy are comparable to that of the U. S. and Western Europe. Considerable credit for the remarkable development of the country must go to the attention Israel has given to the management of its limited water resources. The total water resources are probably more fully understood and more completely utilized than in any other country in the world.

The key to the Israeli system is the national water network, which collects water wherever it is available and transports it to where it is to be used. Approximately two-thirds of the available water is found in the north, while two-thirds of the irrigable land is in the south, where the annual rainfall is less than 5 inches. Consequently, a considerable portion of the water available from the Jordan River is pumped south to the Negev, which was once a desert but is now

an important agricultural area of the country. The division of the Jordan River water has been the source of much friction between Israel and the Kingdom of Jordan. If the Arab states follow their announced intention of diverting the Hasbani and Baniyas Rivers into the Kingdom of Jordan, reducing the flow of the River Jordan, the Israeli water plan will be seriously disrupted and additional international friction will be generated.

In addition to merely redistributing available water, Israel has rather completely inventoried the groundwater resources, drained and made productive the former swamp lands in the Lake Huleh region, taken action to prevent or control seawater intrusion into the coastal aquifers, and trained the farmers in the best methods of rain-fed and irrigated farming.

The available water supplies are used to irrigate about 400,000 acres. Another 600,000 acres is farmed without irrigation.

The entire water program has been supported by detailed planning and by considerable research into such fields as the irrigation needs of various crops, sewage and waste reclamation, artificial recharge of aquifers, evaporation reduction, rainmaking, and desalination. The various water agencies have a combined staff of about 1,800 engaged in planning, design, research, and supervision of projects. This is in addition to university personnel who engage in considerable research.

In the desalination field, Israel has in operation a one-million-gallon-per-day flash evaporation plant at Eilat and a smaller semiexperimental freezing-process plant, also at Eilat. Some work has been done on electrodialysis for conversion of brackish water. With assistance from the U. S., plans are being made for construction of a nuclear power and water plant, probably to be at Ashdod,

on the Mediterranean coast. If built, it will add about 10 percent to the total water supply of the country.

The Israelis have allotted enough of their limited water supply to industrial and community use to build a balanced economy. They are not self-sufficient in food, raising only about 62 percent of their needs, but export considerable quantities of high-value agricultural products, especially citrus fruits, and industrial goods to pay for their needed food imports. Israel today is an outstanding example of the application of technology and sound administration to adapt a nation to its environment.

Kingdom of Jordan

Jordan has an area of about 36,700 square miles, of which about 90 percent is considered to be desert, with practically no rainfall. Present population is approximately 1,700,000 including about 600,000 Palestinean refugees. The rate of increase is in excess of 2.5 percent per year. The known water resources of Jordan consist almost entirely of the water available from the River Jordan and the Yarmouk River, both of which are shared with other countries. There have been differences of opinion for many years over the apportionment of these waters between Jordan and Israel. There is a general opinion that, regardless of other considerations, the amount of land which Jordan can irrigate with this water is probably about 130,000 acres, which could provide food for about 500,000 people.

There is some dry, or rain-fed, farming in the northern part of the country and there have been some projects initiated to build dams in several wadis (normally dry stream beds which carry water after a rain). The practice in these areas is to impound the infrequent rain water, spread it over the land, and raise crops which are supported by the residual moisture. The variability and scarcity of rainfall make both dry farming and wadi farming subject to the whims of nature.

The Central Water Authority of Jordan is responsible for development of the country's water resources. This agency has received considerable assistance from the U. S., both technical and financial, in organizing and training its staff and in carrying on its projects. Programs have been under way to inventory the groundwater resources, to improve the many wells and springs which provide the only water in much of the country, and to utilize the available surface water. The U. N. has also contributed money and technical assistance, including a team of experts to survey the groundwater resources of the Azraq region ($811,000 from the U. N., $417,000 from Jordan), and the assignment of two specialists to help in organizing the hydrological service. The International Development Association has loaned $3.5 million for improvement of urban water supplies.

The largest water project undertaken has been the construction of the East Ghor Canal, which diverts water from the Yarmouk River southward, parallel to the Jordan, through 43 miles of canals, to irrigate 30,000 acres in the Jordan valley. A second phase of this project now in the detailed planning stage is the construction of a storage dam at Maqarin, on the Yarmouk at the Syria-Jordan border. This will provide some hydroelectric power and also permit the diversion of additional water. The East Ghor Canal will be extended almost to the Dead Sea, and a parallel canal will be constructed west of the River Jordan. The total irrigated land when this project is completed will be 125,000 acres. The Maqarin Dam was first proposed in 1953, and was one of the alternatives proposed by Jordan during the negotiations conducted by Eric Johnston in his attempt to find an agreement for division of the River Jordan valley water. Kuwait has now loaned Jordan about $10 million toward the estimated $90 million total cost. The U. S. is also providing financial support.

Still another scheme to add to Jordan's water supply is receiving serious consideration. This is the diversion of water from the Hasbani in Lebanon and

the Baniyas in Syria into the Yarmouk, for use by the Kingdom of Jordan. The problem here is that the Hasbani and the Baniyas are principal tributaries of the River Jordan. The plan would thus divert water which is now an important part of Israel's water plan and is apparently politically, rather than technically, inspired. The diversions of the Yarmouk so far have been in general accord with the various compromise plans which were proposed, but not formally accepted, in the postwar years as means of assuring a fair division of water between the Israelis and the Arabs. The diversion of the Hasbani and Baniyas would be the first major violation of those plans. A number of Arab countries have pledged $20 million to finance the diversion, but it is not yet clear whether it will actually be carried out. It is conceivable that pursuing this plan could result in war between the Israelis and the Arabs.

It seems clear that the presently known water resources available to Jordan are not sufficient to make the country self-supporting in food production. With practically no industry, Jordan has been supported in the past by loans and grants from other countries, principally the U. S. and Great Britain and, more recently, Kuwait. A recent estimate indicated that 63 percent of Jordan's income came from loans and grants. Although most economists argue that the economy of the Middle East must be based on agriculture, it appears that Jordan, at least, should be an exception to this generalization. Irrigated agriculture takes tremendous quantities of water. If a suitable industrial base could be developed, the available water would probably be adequate to support Jordan's present and near-future population. If not, the present rapid growth of population is going to make a bad situation worse.

Some writers have suggested that the only feasible answer to Jordan's economic problems is emigration of a sizable fraction of the population. This might ultimately prove to be the best answer, although it seems unlikely to occur.

Lebanon

Lebanon is the smallest country of the region (4,000 square miles) and is among the smallest in population (approximately 1.8 million). The rate of population increase is high (variously estimated at 2.5 to 3.5 percent per year) and is expected to create problems due to population pressures in the near future. The adult literacy rate is estimated to be at least 50 and perhaps 80 percent. Public health is generally good, relative to other countries of the region, and per capita income is relatively high. More than any of the neighboring countries except Israel, Lebanon's economy is diversified. Agriculture, industry, and construction account for 35 percent of the gross national product, trade and services the remaining 65 percent. About 40 to 50 percent of the people are engaged in agriculture.

Lebanon has one fairly large river, the Litani, and about twelve smaller ones, so that the gross water-supply picture is not bad. Rainfall is higher than is generally found in the Middle East. The principal deterrent to expanded agricultural activity is the shortage of suitable land. Much of Lebanese agriculture is directed to intensive, rather than extensive, cultivation. Much farming is done on terraced hillsides and a good share of the output is in high-value crops (citrus fruits, grapes, apples, bananas, and vegetables). Fertilizers are used extensively and there is considerable irrigation. Yields per acre are generally high.

Irrigation in the past has been largely a matter of individual initiative. Farmers pumped water from nearby rivers or from shallow wells to their fields, or tapped the output of local springs. This kind of approach is somewhat limited in its effectiveness, particularly when agriculture is forced to expand into the less productive lands. In the 1950's the Lebanese government, with

technical assistance from the U. S., began to plan for the orderly development of its rivers for irrigation, for community water supply, and for power production. The largest program is the development of the Litani River basin. This entails construction of three major and five smaller dams, six hydroelectric stations, 210 kilometers of canals, and 41 kilometers of tunnels. When completed (about 1980) it will provide water for the irrigation of 75,000 acres and 170 megawatts of installed electrical capacity, with an annual output of 626 million kilowatt-hours. Total project cost will be in the neighborhood of $100 million, according to early estimates. These are probably optimistic. Major difficulties were encountered in 1959 when a tunnel being drilled to divert water from the Litani to the Awali River collapsed. At the same time, redesign was required for the major dam of the project. These problems have been solved and work is continuing.

The U. S. Bureau of Reclamation made reconnaissance studies of nine river basins in 1957 and 1958, for the purpose of estimating water resources, irrigable land from the point of view of land quality and feasibility of supplying irrigation water, and community water-supply needs. These were actually fairly detailed studies covering almost all of the available surface water in the country and probably will provide the basis for future development as the needs, interest, and resources of the country dictate.

In summary, Lebanon is not nearly so dependent on water as most of the countries of the region are. The people are mostly educated and resourceful and are quite likely to cope with their future problems adequately.

Saudi Arabia

Saudi Arabia is one of the least well known countries of the region. Large and thinly populated (about 8 million people in 870,000 square miles), its contacts with the rest of the world have been rather limited. It is one of the

few true monarchies remaining in the world. Many of the people are nomadic tribesmen, living today much as their ancestors lived in ancient times. Saudi Arabia has several distinctions: it is one of the few countries in the world having no rivers or lakes, it is among the largest producers of crude oil, and it is the center of the Moslem religion. In the few areas of economic activity for which statistics are available (per capita energy consumption, total industrial employment), Saudi Arabia ranks extremely low. Even more than the other Middle Eastern countries, it is a land of sharp contrast between the rich and the poor.

Technical assistance has been provided by the U. S. for a number of years, and more recently by the U. N., in surveying groundwater resources and planning their utilization. Recent reports of a U. N.-sponsored study, conducted by U. S. and Italian firms, indicated that vast groundwater reserves are available at a depth of about 1,500 feet. In the past, pumping of groundwater has been done indiscriminately, with the result that the water table has dropped drastically in some areas and water quality has also deteriorated. This has led to concern that some major cities and irrigated farm areas might be in danger of losing their water supplies.

Previous separate studies of the water supply for Riyadh, the capital city, have been conducted since 1951 by International Bechtel, Michael Baker Company, Hydraulic Afrique, Ralph M. Parsons Company, the Food and Agricultural Organization of the U. N., and the U. S. Geological Survey. There have as yet been few positive steps taken to develop and utilize the country's water resources on a sound basis. As part of the recent flurry of activity, several projects have been planned to dam some of the wadis, in order to collect the infrequent storm runoff, control flooding, and provide for irrigation. Plans have been announced for such projects at the Wadi Jizan ($3.3 million), Abha ($1.4 million), and

Wadi Sahba ($13 million). A German firm has been working on irrigation and drainage studies of the Al-Hasa district, for which the project, including control of shifting sand dunes, is expected to cost $10 million. The Germans are also engaged in a well-drilling program.

The U. N. completed a desalination survey in 1962 which developed some interesting data relative to water supply in the two major cities of Riyadh and Jedda, and in the oil-producing regions of the east. The water supply of Riyadh (estimated population, 170,000) comes principally from wells at Wadi Hanifer. The water table has dropped from 9 meters in 1938 to 50 meters in 1959. The safe yield of this aquifer has been estimated as 20 million cubic meters per year, whereas withdrawals have been about 27 million. As in much of Saudi Arabia, the water is slightly brackish, varying from 500 to 1,000 parts per million salt content. It is interesting to note the distribution of water, in and around the city; irrigated areas receive 12 million gallons per day, the royal palace and grounds receive 3,500,000 gallons per day, and the remainder of the city about 5,500,000 gallons per day. Similarly at Jedda (population 150,000) the groundwater level is dropping seriously because of overpumping, and almost half of the amount supplied to the city goes to a palace and other residential areas occupied by the royal family.

Saudi Arabia has indicated interest recently in large-scale desalination plants. In October, 1965, an agreement was signed with the U. S. on a joint endeavor to study a nuclear plant to produce five million gallons of water per day and 36 megawatts of power. Total cost of the plant, if built, will be about $14 million. The U. S. will provide the design.

Saudi Arabia is presently able to grow only about half of its food supply. Except for some oil refining (about 10 to 15 percent of the total crude-oil output), the country has essentially no industry. If recent optimistic reports

regarding groundwater availability are true, careful management of this water could expand the agricultural output and provide water for industry. What is needed is a determination on the part of the government to make and implement well-conceived development plans. A further urgent need is for trained administrators and technical personnel, who are presently in very short supply.

Syria

Syria has an area of about 74,000 square miles and a population of approximately 5.5 million. It has been estimated that 15 million acres are suitable for agriculture, of which about half is now in use. Less than 20 percent of the land which is farmed is irrigated. Syria has 12 rivers, numerous springs, and considerable quantities of good water. The population density per unit of cultivable land is moderately low. Unlike some other countries of the region, such as the UAR. Syria is not facing the problem of excessive population in the near future. Nevertheless, the country is not prosperous. Indicators such as unit gross national product, literacy rate, per capita power consumption, and numbers of doctors and hospital beds place Syria at about the average for the region, or a little below.

Most of the people earn their livelihood from agriculture (probably 70 percent) and most of these are engaged in dry farming. Rainfall is generally 10 to 20 inches per year, with a summer dry season. Principal crops are wheat, barley, and cotton. The resulting economic problems are typical of what can be expected in a region of marginal and highly variable rainfall. Crop production fluctuates widely from year to year, depending on the weather. Income is affected by the variation in production and also by fluctuations in the world commodity market for a very few products. In this kind of an economic environment, there is a tendency for the small independent farmer to be squeezed out because of his

lack of resources to carry over the bad years. As a result, land ownership is concentrated in very large holdings, with the majority of the farmers being tenants. This has been the traditional pattern in the Middle East, with the result that poverty, inefficiency, and ignorance perpetuate themselves. Political instability adds to the problem, because of the inability of governments to carry out long-range plans for major improvements.

Recent years have brought a renewed interest and effort by the Syrian government to bring about some major improvements in the economy. A number of sizable programs have been started or completed which have the objective of providing enough irrigation water to increase the irrigated area from 1.2 million acres (in 1964) to 1.8 million acres. With irrigation, crop yields can be increased and stabilized, and more diversification in crops can be realized. Land-reform programs have been initiated to redistribute the large holdings into small farms, with the government providing long-term credit to the farmers. As often happens, the program has been slow to produce results.

In water-resources development, recent major projects include the following:

The Euphrates Project. This is the largest of the projects. It was studied and restudied for several years before a firm decision was reached to proceed. The final decision was to build a dam at Tapqa, on the Euphrates River, to impound a large reservoir from which irrigation water can be provided to an area variously reported as 190,000 to 500,000 acres. Hydroelectric power will be generated, initially 200 megawatts with an ultimate potential of 700 megawatts. The plan provides for 30 pumping stations, requiring 70 megawatts of power, to move much of the irrigation water to regions upstream of the dam. Also included are about 1,000 kilometers of canals and drainage ditches, new villages, schools, and roads and plans to train the farmers in the methods of irrigation agriculture.

Total estimated cost of the basic project (the dam, power plant, and distribution system) is $260 million. West Germany loaned $87 million (20-year repayment at 3.75 percent interest); the balance of the cost will be paid by Syria. When the project is completed (estimated to be 1970) it is expected to raise Syria's agricultural income about 20 percent.

Al-Ghab Project. This is a multiphase project for development of a portion of the Orontes River and the land adjacent to it, which was started in 1950. It included draining of large marsh areas, construction of 580 miles of irrigation canals, and construction of two dams. The dam at Rastan, completed in 1961 at a cost of $8 million, stores 250 million cubic meters of water and provides for the irrigation of 60,000 acres. The barrage at Mahared was started in 1962. It provides 61 million cubic meters of storage and will also irrigate 60,000 acres. The dams were designed by Swiss engineers and built by a Bulgarian company, with financing entirely by Syria. A small amount of power is generated and sent to Homs and Hama. Cost of the entire project is variously reported to be $20 million to $40 million.

Other Projects. Other projects which are in the planning or early construction stages include:

(1) The Orontes, to irrigate 30,000 acres at a cost of $13 million

(2) The Barada, to irrigate 30,000 acres and generate 10 megawatts of power, at a cost of $10 million

(3) The El-Sinn, to irrigate 25,000 acres at a cost of $4.5 million

(4) The Roudj, to irrigate 12,000 acres at a cost of $3.5 million

(5) The Khabour, to irrigate 150,000 acres at a cost of $25 million.

In addition to these impoundment schemes for the utilization of surface water, some recent effort has been expended in searching for groundwater. An

extensive survey was made of the Jezireh area in the Northeast, between the Tigris and Euphrates Rivers. Large quantities of usable groundwater were found throughout the region. This survey, completed in 1963, was a U. N. Special Fund project, the U. N. contributing $472,000 to its cost and the Syrian government $570,000. Other groundwater surveys are anticipated.

The U. N. has also provided assistance in the design and execution of irrigation projects, planning the agricultural development of the Ghab region, and organization of the hydrological service.

As with some other countries of the region, the ingredients necessary for improvement of the agricultural economy appear to be present. Firm guidance and capable administration by the government, and education of the farmers to fit into a modernized agricultural society are needed if the potential of the country is ever to be realized.

BIBLIOGRAPHY

(1) United Nations Publication E/3881, "Water Resources Development Center, Third Biennial Report", Economic and Social Council, Official Records, 37th Session, Supplement No. 13 (1964).

(2) Grunwald, Kurt, and Ronall, Joachim, Industrialization in the Middle East, Council for Middle Eastern Affairs Press (1960).

(3) Dieterich, Bernd H., and Henderson, John M., "Urban Water Supply Conditions and Needs in 75 Developing Countries", Public Health Papers, No. 23, World Health Organization, Geneva (1963).

(4) "U. N. Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas", Geneva (1963).

(5) Peretz, Don, "River Schemes and Their Effect on Economic Development in Jordan, Syria and Lebanon", Middle East Journal, 18 (3), 293-305 (1964).

(6) "Report of the Africa-Eastern Mediterranean Seminar on Community Water Supply", Addis Ababa (1960).

(7) United Nations Publication E/CN.11/688, "Technical Assistance Provided to Countries and Territories of the ECAFE Region Under the Expanded and Regular Program" (1965).

(8) United Nations Publication E/4016, "Technical Assistance Activities of the U. N." (1965).

(9) Brown, Glen F., and Lough, Charles F., "Water Supply for Riyadh, Saudi Arabia", U. S. Geological Survey, Foreign Hydrology Branch, Internal Report (1963).

(10) Lieberman, Morton W., "Report on Proposed National Water Resources Commission for Iran", U. S. Agency for International Development, Tehran, Iran (1962).

(11) United Nations Publication E/CN.11/L.111, "Fifth Regional Conference on Water Resources Development", Economic Commission for Asia and the Far East.

(12) United Nations Publication E/3863, "Proposals for a Priority Program of Coordinated Action in the Field of Water Resources Within the Framework of the Development Decade" (1964).

(13) United Nations Publication E/3904, "Development of Natural Resources" (1964).

(14) United Nations Publication E/3990/Corr 1, "Technical Assistance Activities of the U. N." (1964).

(15) "The Arab World; Paths to Modernization", Journal of International Affairs, XIX (1) (1965).

(16) "Industrial Progress in the U. A. R.", U. A. R. Information Center, Embassy of United Arab Republic, Washington, D. C. [1964(?)].

(17) Clarke, Frank E., "Appraisal of Corrosion Characteristics of Western Desert Well Waters, Egypt", U. S. Geological Survey, Cairo (1963).

(18) "Discovery of Underground Water Brings Prosperity to an Arid Region of Egypt", Illustrated London News, 245, 300-301 (August 29, 1964).

(19) Waite, Herbert A., and Hussein, Idris, "Status of Hydrogeological Investigations in the New Valley Project, Western Desert, Egyptian Region, United Arab Republic", International Association of Scientific Hydrology, Publication No. 56, Athens (1961).

(20) "UAR Desert Development and Land Reclamation Projects", General Desert Development Organization, Cairo (1961).

(21) "The United Arab Republic, Egypt", UAR Information Center, Embassy of United Arab Republic, Washington, D. C. [1964(?)].

(22) White, Gilbert F., "Science and the Future of Arid Lands", UNESCO, Paris (1960).

(23) Bergman, Elihu, "Iran's TVA", The Progressive, 28, 20-23 (April, 1964).

(24) "Water and Power for Modern Iran", Compressed Air Magazine, 67, 16-17 (February, 1962).

(25) "Stemming the Floods of a Thousand Years", Engineering, 195, 466 (April 5, 1963).

(26) "Electric Power in Asia and the Far East", United Nations (1964).

(27) Harza, R. D., and Edbrooke, R. F., "Design of Karadj Hydroelectric Project", Proceedings, American Society of Civil Engineers, 86, 31-50 (August, 1960); 87, 103-106 (November, 1961); 88, 145-147 (December, 1962).

(28) "Multiple Purpose River Basin Development, Part 20, Water Resources Development in Afghanistan, Iran, Republic of Korea and Nepal", United Nations, Flood Control Series No. 18 (1961).

(29) "Iran Builds Record High Dam", Engineering News-Record, 170, 41 (May 16, 1963).

(30) Muse, Victor E., "From Ancient Ghanats to Modern Water Wells for Iran", Water Works Engineering, 114, 962-965 and 990-991 (October, 1961).

(31) Stevens, Charles S., "Community Water Supply Development in Iran", Journal of the American Water Works Association, 55, 1133-1140 (1963).

(32) Clapp, Gordon R., "Iran: A TVA for the Khuzistan Region", The Middle East Journal, 11 (1), 1-11 (1957).

(33) Langley, Kathleen, M., "Iraq: Some Aspects of the Economic Scene", Middle East Journal, 18 (2), 180-188 (1964).

(34) "Al-Assi Project: A New Hope for the Northern Region", Arab Review, 1, 48-51 (August, 1960).

(35) Butler, Stanley S., "Irrigation Systems of the Tigris and Euphrates Valleys", Proceedings of the American Society of Civil Engineers, 86, 59-79 (December, 1960); 87, 73-74 (June, 1961); 87, 77 (December, 1961).

(36) "Storming the Nile", New Times (Moscow), (April 29, 1964), pp 19-20.

(37) "Aswan's First Stage Completed", Engineering News-Record, 172, 55-58 (May 21, 1964).

(38) "Aswan Dam: Stage 2 Begins", Engineering, 197, 732-733 (May 29, 1964).

(39) "Rastan Dam - Syrian Irrigation Structure Completed", Civil Engineering, 33, 82 (June, 1963).

(40) "Desert May be Green Again", Engineering News-Record, 169, 51 (August 23, 1962).

(41) "The Nahr El-Asi Project", New Times (Moscow), No. 6, 12-13 (1961).

(42) Schneider, Georg, "The Euphrates Dam Project", Germany, The Magazine of the Federal Republic, 8 (34), 30-32 (1963).

(43) Wafa, Taher Abu, "The Social and Economic Consequences of the High Aswan Dam", Impact, XIII (4), 253-272 (1963).

(44) "Engineering Management of Water Supplies, Near East - South Asia Regional Seminar, Tehran, Iran, 1961", International Cooperation Administration.

(45) Wiener, Aaron, and Wolman, Abel, "Formulation of National Water Resources Policy in Israel", Journal of the American Water Works Association, 54, 257-263 (March, 1962).

(46) "The Jordan Water Problem", American Friends of the Middle East, Inc., Washington, D. C. (1964).

(47) Prushansky, Yehoshua, "Water Development, Israel Today, No. 11, published by Israel Digest, Jerusalem (1964).

(48) "The Israel National Water Plan", United Asia, 16, 52-56, (February, 1964).

(49) Garbell, Maurice A., "The Jordan Valley Plan", Scientific American, 212 (2), 23-31 (March, 1965).

(50) Regev, Ariel, "A Study of Israeli Water Resources and Water-Development Projects", Translation by United States Joint Publications Research Service, New York from Etger, 1 (1), (April, 1960), Tel Aviv, Israel.

(51) Claney, Harry F., "Utilization of Water and Irrigation in Israel", Proceedings of the American Society of Civil Engineers, 88, 55-56 (June, 1962); 88, 69-70 (December, 1962); 89, 79-80 (June, 1963).

(52) "Water--To Work or to Waste", Near East Report, 8, 5-7 (January 14, 1964).

(53) Clarke, Frank E., "Water Problems in a Thirsty World", Engineers Society of Western Pennsylvania, Proceedings of 24th Annual Water Conference (1963), pp 1-5.

(54) "Report of the United States-Israel Desalting and Power Team" (October, 1964).

(55) "Sand-Filled Water Tunnel Holed Through", Engineering News-Record 174, 20-21 (May 6, 1965).

(56) "Stalled Litani Project Studied", Engineering News-Record, 166, 44 (March 30, 1961).

(57) "Summary Report: Water Resources Investigations of the Nahr Ostouene, Nahr Arka, Nahr El Bared, Nahr Abou Ali, Nahr Ibrahim, Nahr El Kelb, Nahr Beirut, Nahr Damour and Nahr El Assi Basins, Republic of Lebanon", U. S. Department of the Interior, Bureau of Reclamation, Denver, Colorado (1958).

(58) "Ancient Water Tapped", Science News Letter, 68, 277 (October 30, 1955).

(59) Willimott, S. G., Birch, B. P., McKee, R. F., and Atkinson, K., "Qatrana and Sultani Dams Projects in Jordan", World Crops, 17 (2), 44-49 (June, 1965).

(60) Le Fever, Floyd F., "National Hydrologic Service and Programs in Jordan - Evaluation and Recommendations", U. S. Geological Survey (September, 1962).

(61) Murray, C. Richard, "Recommended Program of Ground-Water Studies for the Jordan Valley and Suggested Training Program for Jordanian Ground-Water Hydrologists", U. S. Geological Survey (October, 1962).

(62) "Development Plans: Appraisal of Targets and Progress in Developing Countries", United Nations, New York (1965).

(63) "Economic Developments in the Middle East, 1961-1963", United Nations, New York (1964).

(64) "FAO Mediterranean Development Project", Food and Agriculture Organization of the United Nations, Rome, Italy (1959); also individual country reports for Iraq, Syria, Lebanon and Israel.

(65) "Water Desalination in Developing Countries", United Nations, New York (1964).

(66) "Development of Israel and Its Search for Water", Illustrated London News, 244, 950 (June 13, 1964).

(67) U. N. Report E/3871/Rev 1, Technical Assistance Committee, "Annual Report to the Technical Assistance Board for 1963".

(68) "Report on the Technical Discussions on the Influence of Community Water Supply Programs on Health and Social Progress", World Health Organization, Seventeenth World Health Assembly (1964).

(69) "Fresh Water Shortage in Middle East", The Daily Star, Beirut, Lebanon (November 17, 18, 19, and 20, 1964).

(70) "Water Carries the Seeds of War", The Washington Star, Washington, D. C. (November 11, 1965).

(71) De Carvalho, George, "An Ancient Hatred Builds Toward War", Life, 58 (24), 44-50, 54, 58-62 (June 18, 1965).

(72) "Egyptian Revolution Hurries Past Fellah", The Columbus Dispatch, Columbus, Ohio (June 17, 1965).

(73) Longrigg, S. H., The Middle East, Aldine Publishing Company, Chicago (1963).

(74) Halpern, Manfred, The Politics of Social Change in the Middle East and North Africa, Princeton University Press, Princeton, N. J. (1963).

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13. ABSTRACT

The water resources of the Middle East (including specifically the United Arab Republic, Iran, Iraq, Israel, Jordan, Lebanon, and Saudi Arabia) and the management, development, and utilization of the water resources are discussed in this report. Also considered is the adverse effect of shortages of trained personnel and of illiteracy on the effectiveness of the existing water-resources programs. Establishment of a Middle East Water Institute is recommended.

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UNCLASSIFIED

Security Classification

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Security Classification

	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Water Resources	8,9					
Middle East	9					
United Arab Republic	9					
Iran	9					
Iraq	9					
Israel	9					
Jordan	9					
Lebanon	9					
Saudi Arabia	9					
Development	8,7,1					
Utilization	8,7,9,1					
Shortages	6					
Personnel	9					
Trained	0					
Illiteracy	6					
Effectiveness	7					
Management	8,7,9,1					
Establishment	8,10					
Organizing	8,10					
Water Institutes	2,10					
Improving	4,8					

UNCLASSIFIED

Security Classification